

## Letters to the Editor

### Response to 'Comments on Workshop Report on the Economic and Environmental Impacts of Biobased Production'

Young AL (2005): Comments on Workshop Report on the Economic and Environmental Impacts of Biobased Production by Amy E. Landis and Thomas L. Theis [Int J LCA 10 (3) 226–227 (2005)]. Int J LCA 10 (4) 233–234

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We thank Young for the interest in the 'Workshop on the Economic and Environmental Impacts of Biobased Production' and for the perceptive observations. The substance of the comments provided by Young (2005) is that there are extraordinary things happening with respect to biobased research in terms of visions for creating new biobased products, government biobased procurement policies, and the use of life cycle assessment (LCA) by government agencies for several soy-based products. While these are no doubt true, the aims of the Workshop were to avoid uncritical praise, but instead to *critically examine* this area and the environmental implications that further growth might lead to.

Research into the environmental implications of agriculturally based feedstocks focuses particularly on global warming and fossil fuel use while neglecting other environmental impacts. These two issues have risen to prominence partly because they resonate with a specific socio/political or economic agenda, such as energy independence or support of crop prices. To address the en-

tirety of environmental implications, we in the research community must continually ask, "What does 'green' really mean? Does this definition of 'green' really produce environmentally preferable products? Who will be supplying these 'green' feedstocks?" The 'Workshop on the Economic and Environmental Impacts of Biobased Production' addressed such questions (Landis and Theis 2005). It was demonstrated that increased biobased production will require careful management to avoid detrimental agricultural repercussions and that the growth of biobased production will involve many nations, both developed and developing. Both of these topics were identified as areas of research within biobased production that are deserving of greater attention.

For example, non-point aqueous emissions are often neglected entirely while other EPA criteria air pollutants are included in only a select few projects investigating the environmental impacts of biobased production. Table 1 contains a summary of recent studies on the environmental effects of bioproduction.

**Table 1:** Biobased LCAs. The analyses listed below either included chemicals that typically contribute to the following categories or included a separate impact assessment for the following impact categories: GW=global warming, FF=fossil fuel use, EH=eutrophication, HH=human health (including air quality, carcinogenicity, human toxics, and smog), H<sub>2</sub>O=water use, EQ=ecosystem quality (including acidification and soil health), LU=land use

LCA reference	Bio-product	Environmental impacts included						
		GW	FF	EH	HH	H <sub>2</sub> O	EQ	LU
Akiyama (2003)	Polyhydroxyalkanoate	X	X					X
Dornburg (2003)	Polymers	X	X					X
Fu (2003)	Ethanol	X	X	X	X		X	
Gerngross (2000)	Polyhydroxyalkanoate, polylactic acid	X	X					
Jungmeier (2001)	Bioenergy	X	X					X
Kadam (2002)	Ethanol	X	X	X	X		X	
Kim (2005 a)	Ethanol	X	X					
Kim (2005 b)	Polyhydroxyalkanoate	X	X	X	X		X	
Kurdikar (2000)	Polyhydroxyalkanoate	X						
Lynd (1996)	Ethanol	X	X		X*			
Lynd (2003)	Polyhydroxyalkanoate, ethanol		X					
McManus (2003)	Biolubricant	X	X	X	X		X	
Patel (1999)	Biofuels & Surfactants	X	X					
Shapouri (2002)	Ethanol		X					
Sheehan (1998)	Biodiesel	X	X		X	X	X	
Sheehan (2002)	Ethanol	X	X		X		X	
Sheehan (2003)	Ethanol	X	X		X		X	X
Slater (2002)	Polyhydroxyalkanoate, polylactic acid	X	X					
van den Broek (2001)	Bioenergy	X	X	X	X		X	
Vink (2003)	Polylactic acid	X	X			X		

\* Lynd 1996 provides estimates from NO<sub>x</sub> only resulting from the tailpipe for the combustion of ethanol, these emissions are not directly related to human health impacts within the reference.

Clearly the research community thus far has shown preference for contaminants that cause greenhouse impacts as well as for aggregating fossil fuel consumption, with relatively few examining other types of environmental degradation. Because the primary purpose of a LCA is to elucidate the environmental trade-offs concomitant to design alternatives, it behooves us to thoroughly investigate the environmental implications of biobased production, especially with respect to agriculturally important impacts such as eutrophication and hypoxia.

Although estimating environmental impacts such as global warming and fossil fuel use is extremely important, there are a multitude of other contemporary environmental problems associated with the production of agricultural feedstocks. Nitrogen and phosphorus emissions from agriculture are the primary contributors to hypoxia and eutrophication (Smil 2000, Galloway, Aber et al. 2003). Minute amounts of phosphorus within runoff can contribute significantly to eutrophication, while nitrate in water bodies is responsible for acidification, eutrophication and hypoxia, leading to a loss of biodiversity and natural habitats. Pesticides in runoff are also hazardous to human and/or ecological health (Pereira and Hostettler 1993). Air emissions from agricultural systems are also of concern with respect to human health; they typically originate from the combustion of fuels, the application of fertilizers and pesticides, and particulate matter created during tillage. Air emissions such as NO<sub>x</sub>, SO<sub>x</sub>, particulate matter, and volatilized pesticides contribute negatively to human health and ecosystem quality. Intensive farming and erosion can also result in soil degradation. The environmental impacts of genetic engineering (GE), such as the effects on non-target organisms, mutations, resistance, and invasiveness, are not quantified in traditional environmental impact analyses (Gaugitsch 2002). GE is used to increase crop yield, enhance certain desired crop traits, and cause plants themselves to produce readily extractable monomers for biocommodities (Poirier 1999, Kurdikar et al. 2000).

The aims of the workshop were to *expand* the dialogue on biobased production into new areas of concern, such as global economies and agricultural environmental impacts, and to seek a synthesis among the many facets of this topic including life cycle concerns, economic and policy elements, and business, academic, and government agendas. More research that attempts to answer questions posed by the Workshop will help to drive the growth of biobased production along an informed and sustainable path.

## References

- Akiyama M, Tsuge T, Doi Y (2003): Environmental life cycle comparison of polyhydroxyalkanoates produced from renewable carbon resources by bacterial fermentation. *Polymer Degradation and Stability* 80 (1) 183–194
- Dornburg V, Lewandowski I, Patel M (2003): Comparing the land requirements, energy savings, and greenhouse gas emissions reduction of biobased polymers and bioenergy. An analysis and system extension of life-cycle assessment studies. *Journal of Industrial Ecology* 7 (3–4) 93–116
- Fu GZ, Chan AW, Minns DE (2003): Life cycle assessment of bio-ethanol derived from cellulose. *Int J LCA* 8 (3) 137–141
- Galloway JN, Aber JD, Erisman JW, Seitzinger SP, Howarth RW, Cowling EB, Cosby BJ (2003): The Nitrogen Cascade. *BioScience* 53 (4) 341–356
- Gaugitsch H (2002): Experience with environmental issues in GM crop production and the likely future scenarios. *Toxicology Letters* 127 (1–3) 351–357
- Gerngross TU, Slater SC (2000): How green are green plastics? *Scientific American* 283 (2) 37–41
- Jungmeier G, Spitzer J (2001): Greenhouse gas emissions of bioenergy from agriculture compared to fossil energy for heat and electricity supply. *Nutrient Cycling in Agroecosystems* 60 (1–3) 267–273
- Kadam KL (2002): Environmental benefits on a life cycle basis of using bagasse-derived ethanol as a gasoline oxygenate in India. *Energy Policy* 30 (5) 371–384
- Kim S, Dale BE (2005a): Environmental aspects of ethanol derived from no-tilled corn grain: nonrenewable energy consumption and greenhouse gas emissions. *Biomass and Bioenergy* 28 (5) 475–489
- Kim S, Dale BE (2005b): Life cycle assessment study of biopolymers (polyhydroxyalkanoates) derived from no-tilled corn. *Int J LCA* 10 (3) 200–209
- Kurdikar D, Fournet L, Slater SC, Paster M, Gerngross TU, Coulon R (2000): Greenhouse gas profile of a plastic material derived from a genetically modified plant. *Journal of Industrial Ecology* 4 (3) 107–122
- Landis AE, Theis TL (2005): Workshop on the Economic and Environmental Impacts of Biobased Production. *Int J LCA* 10 (3) 226–227
- Lynd LR (1996): Overview and evaluation of fuel ethanol production from cellulosic biomass: technology, economics, the environment, and policy. *Annu Rev Energy Environ* 21 (1) 403–465
- Lynd LR, Wang MQ (2003): A Product-Nonspecific Framework for Evaluating the Potential of Biomass-Based Products to Displace Fossil Fuels. *Journal of Industrial Ecology* 7 (3–4) 17–32
- McManus MC, Hammond GP, Burrows CR (2003): Life-Cycle Assessment of Mineral and Rapeseed Oil in Mobile Hydraulic Systems. *Journal of Industrial Ecology* 7 (3–4) 163–177
- Patel M, Reinhardt GA, Zemanek G (1999): Vegetable oils for biofuels versus surfactants. An ecological comparison for energy and greenhouse gases. *Fett/Lipid* 101 (9) 314–320
- Pereira WE, Hostettler FD (1993): Nonpoint source contamination of the Mississippi River and its tributaries by herbicides. *Environmental Science and Technology* 27 (8) 1542–52
- Poirier Y (1999): Green chemistry yields a better plastic. *Nature Biotechnology* 17 (10) 960–961
- Shapouri H, Duffield JA, Wang M (2002): The Energy Balance of Corn Ethanol: An Update. Washington DC, US Department of Agriculture: Economic Research Service
- Sheehan J, Aden A, Paustian K, Killian K, Brenner J, Walsh M, Nelson R (2003): Energy and environmental aspects of using corn stover for fuel ethanol. *Journal of Industrial Ecology* 7 (3–4) 117–146
- Sheehan J, Camobreco V, Duffield J, Graboski M, Shapouri H (1998): Life Cycle Inventory of biodiesel and petroleum diesel for use in an urban bus, final report. Golden, CO, National Renewable Energy Laboratory
- Sheehan J, Riley C, Lightle D, Walsh M, Cushman J, Paustian K, Killian K, Brenner J, Nelson R (2002): Is Ethanol from Corn Stover Sustainable? Adventures in cyber-farming: A life cycle assessment of the production of ethanol from corn stover for use in a flexible fuel vehicle. National Renewable Energy Laboratory, US Department of Agriculture, Oak Ridge National Laboratory.
- Slater S, Glassner D, Vink E, Gerngross T (2002): Evaluating the Environmental Impacts of Biopolymers. Biopolymers. Steinbuechel A (ed), Weinheim, Wiley-VCH. 10, 473–492
- Smil V (2000): Phosphorus in the Environment: Natural Flows and Human Interferences. *Annu Rev Energy Environ* 25, 53–88
- van den Broek R, Meeusen M, Treffers D-J, van Wijk A, Nieuwlaar E, Turkenburg W (2001): Green Energy or Organic Food? A Life-Cycle Assessment Comparing Two Uses of Set-Aside Land. *Journal of Industrial Ecology* 5 (3) 65–87
- Vink ETH, Rabago KR, Glassner DA, Gruber PR (2003): Applications of life cycle assessment to NatureWorks polylactide (PLA) production. *Polymer Degradation and Stability* 80 (3) 403–419
- Young AL (2005): Comments on Workshop Report on the Economic and Environmental Impacts of Biobased Production. *Int J LCA* 10(4) 233–234